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FUTURE PERFORMANCE TREND INDICATORS: A CURRENT VALUE APPROACH T--ETC(U)

AUG 78 D G BOWERS, A S DAVENPORT

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are given, as are recommendations for additional areas of investigation into theoretical and utilization issues.

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FUTURE PERFORMANCE TREND INDICATORS:  
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REPORT VII  
UTILIZATION PROBLEMS TIED TO METHODOLOGICAL ISSUES

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By:  
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David G. Bowers  
Alan S. Davenport

Institute for Social Research  
The University of Michigan  
Ann Arbor, Michigan

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## I. INTRODUCTION

The earlier reports in this sequence have provided a basis for, and demonstrated, a system of future performance trend indicators, that is, a current value form of human resources accounting. The purpose, of course, is to provide a system which monitors those present human organization changes which are likely to result in changes in future performance.

In a best of all possible worlds, one would expect that implementation and utilization of such a system would be no problem. Once successfully demonstrated, managers would presumably rush to adopt this human factor "early warning system." As we are all well aware, however, utilization of new research findings does not occur all that readily. Despite the pure researcher's articles of faith, solid findings do not sell themselves.

Instead, utilization occurs more nearly as the result of the ability of the two communities -- the research system and the user system -- to interact constructively and to speak each other's language, replicate each other's thought processes, worries, and concerns (Caplan, 1973; Havelock, 1973, 1973).

Some of these concerns are methodological in origin. They reflect differences in procedures, methods, and concepts of sharing, processing, and analyzing information. Like unfamiliarity in any setting, these differences produce mistrust and wariness. For example, social and behavioral science deal customarily in probabilities, while accounting deals more nearly in complete certainties. The organizational scientist is therefore pleased with the 50 percent of outcome variance which is accounted for, while the accountant sees the half that remains unknown and treats the results with some skepticism.

Although there are obviously other sources of potential resistance to implementing the findings of this series of reports -- such as preferences for management styles at odds with those which underlie the prediction system, or affinity only for hardware rather than the human organization, it is to some methodological questions and obstacles that this last technical report turns. Our belief is that major progress in implementing a current value HRA system may be made by addressing them in some detail.

The sections which follow accordingly treat a number of these issues in fairly formal and technical fashion. The basic questions may be stated much more informally, however:

- (1) Aren't the predictions made in these reports really rather marginal? Isn't there a great deal of unaccounted-for variance in outcomes, more even than what is accounted for?
- (2) Aren't such things as dollar value, discounting, and capitalization commercial-world notions that are rather irrelevant to a military setting?
- (3) Doesn't this research take a great deal for granted about what should and should not be included in a set of predictors for current value HRA?
- (4) Isn't any system that predicts across time of limited usefulness to an organization, like the Navy, which has constant reorganization and turnover?
- (5) Doesn't this research, if implemented, imply levels and frequencies of reporting that would overtax the system?

Obviously, no ringing denial of these potential problems is possible. However, an exploration of the issues that are involved may well scale some of them down to manageable size. Accordingly, in the sections which follow, each of these topics is examined in some detail as regards methodological problems bearing upon them.

## II. ISSUES OF ADEQUACY OF PREDICTION

The selection of appropriate performance variables to be used as criterion measures is a complex, but often oversimplified, procedure. Two articles which discuss relevant issues (Macy & Mirvis, 1976; Mirvis & Macy, 1976) in the identification of productivity measures conclude that, while it is difficult to select such measures, it is exactly these measures which are central to the assessment of an organization.

In any measure, be it criterion or predictor, the questions of reliability and validity arise. Reliability of performance data is not only a function of recording errors, but also internal pressures for "high" performance, or punishment for poor performance. While deliberate misrepresentation may not be a major problem in itself, coupled with other error sources (possibly including inappropriate data collection systems), the result is performance measurements with far less than perfect reliability.

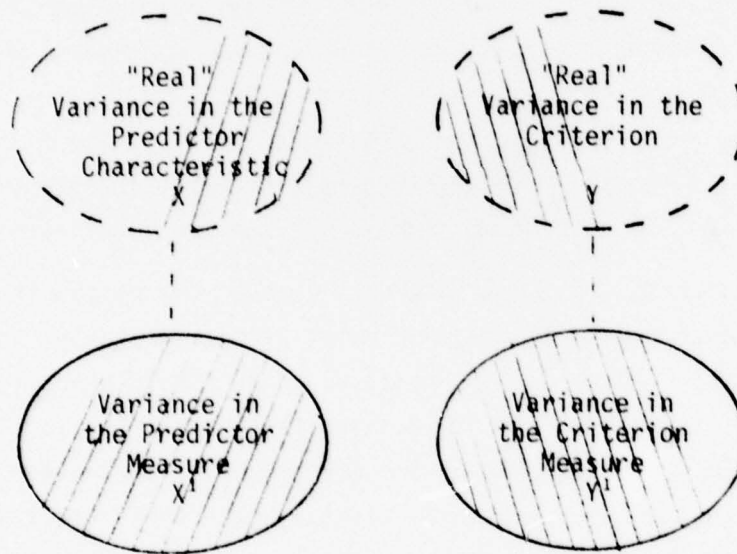
At the outset, it's important that we note the distinction between the real predictor and outcome properties (those that exist in the real world as actual events) and our measures which simply operationalize them. The degree of support present in a supervisor's behavior is a real property of the system, of which our questionnaire three-item index is simply a reflection. In a similar fashion, real performance is something different from the measures which we use to represent it.

These operational measures may be more or less "good" -- that is, in some measure they represent true variance in the predictor characteristic, or true variance in the criterion, but in some measure they contain both systematic and random error as well. To extend our example, to some degree a particular index value on supervisory support reflects the actual degree of supportiveness present in that supervisor's behavior in a recent time period, but to some degree it represents as well such unrelated things as positive or negative response set and random error. In like fashion, our criterion measure -- for example, an index of absenteeism -- reflects in part real absenteeism and in part such things as a timekeeper's favoritism and random, erroneous entries.



We assess the degree of "goodness" of our measures by commonly accepted indexes of reliability and validity, yet these may be in some ways insufficient. Systematic error may be quite reliable, and a high correlation between predictor and criterion may reflect the coincidence of related systematic error more than the overlap of true effects. As writers and scholars in the selection field noted long ago, we cannot safely assume the adequacy of the criterion and conclude that inadequacy lies only in the predictor. Although it seems at first glance quite counterintuitive, we might conceivably encounter a situation in which an excellent measure of supervisory support relates not at all to a measure of absenteeism which contains largely error.

Figure 1

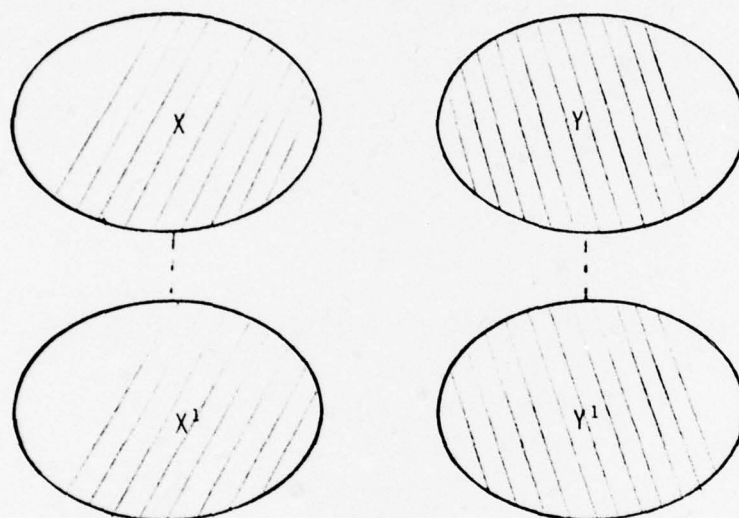


Let's consider these issues a bit further. Figure 1 shows both real characteristics and operational measures for both predictor and criterion, with cross-hatching to denote particular sub-segments of variance. In the operational measures ( $X^1$  and  $Y^1$ ), the cross-hatched area represents that portion of the measure which reflects true criterion variance. In the illustration, a large proportion of variance in the operational measures is shown as "true." The cross-hatched area of the "real" measures ( $X$  and  $Y$ ) represents this same portion of true variance

plotted against the sum of all true variance in the real predictor and criterion, respectively. As illustrated, this segment is relatively smaller in relation to total true variance than when represented as a proportion of variance in the operational measures.

Now consider a somewhat more complicated situation, represented in Figure 2. Once more, cross-hatching is used to depict areas of overlap.

Figure 2



In this instance, the operational predictor is a reasonably adequate (accurate, complete) reflection of the real predictor, and the operational criterion measure is only slightly less so. But, if we use position inside the oval as meaningful (i.e., as reflecting particular segments of variance), it is apparent that the operational predictor relates to real criterion variance not measured by the operational criterion.

Figure 3 extends this and integrates it.

Figure 3a

Covariance in Real Predictor and Criterion

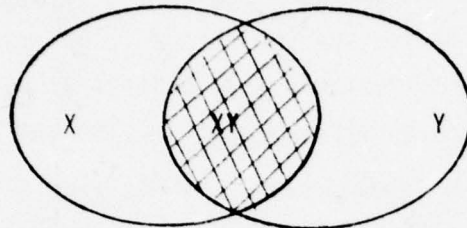
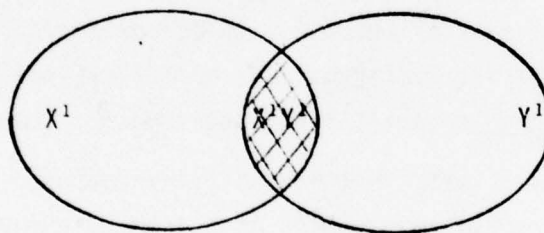


Figure 3b

Covariance in Operational Predictor and Criterion



The upper portion of the figure (Figure 3a) represents real predictor-criterion overlap, while the lower portion (Figure 3b) represents the overlap present in the operational measures. The latter is considerably smaller than the former, and a coefficient that we would obtain in actually correlating these two operational measures might seriously understate the size of the real relationship.

However, the situation may be even more complex when one considers that some proportion of the operational measures is error. The cross-hatched segment labelled  $X^1Y^1$  in Figure 3b may, in fact, be as large as (contain all of) what is labelled  $XY$  in Figure 3a, but produce a lower-than-warranted coefficient simply because it is watered down by large amounts of error in the operational measures.

A more troublesome situation is that depicted in Figure 4.

Figure 4a

Covariance in Real Predictor and Criterion

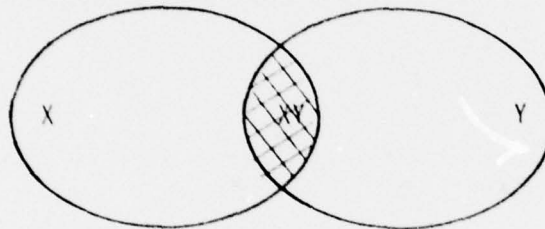
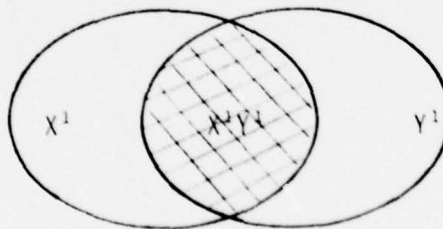


Figure 4b

Covariance in Operational Predictor and Criterion



The upper portion of this figure indicates relatively small overlap, while the lower portion shows that the operational measures assess this as comparatively larger. This could occur for either of two reasons: (a) because the operational measures contain relatively little error, but are simply low in the proportion of the real variance that they represent (though what they have is largely covariance), or (b) because the



operational measures contain -- beyond whatever legitimate covariance they have -- correlated error (systematic error covariance.)

Troublesome as this is, we should note that it represents a situation that is likely to go unrecognized, for the simple reason that the operational criterion measures are inadequate, and it is to these measures -- adequate or inadequate -- that users attend. A great ability to predict an inadequate criterion is applauded, whereas an inability to predict that same criterion is treated as a shortcoming of the predictor, even though the latter may bear a close relationship to real criterion variance.

So while it is possible to "overpredict" because of accurate but inadequate measures, this event seems unlikely to be troublesome from a user point of view for the simple reason that unknown criterion variance is just that -- unknown.

The alternate form of this same situation -- covariant systematic error -- is intended to be minimized by having multiple measures collected by different methods from different sources and in different situations. Collecting more than one measure of absenteeism, by somewhat different methods in a variety of organizations, and relating them to multiple questionnaire predictors similarly collected in a variety of settings hopefully reduces the likelihood that covariant systematic error will substantially "kite" the obtained coefficient.

Indeed, it is "underprediction," rather than "overprediction," that ought and does concern us most. In this present study,  $R$ 's of .50 -- good as they are by comparison to past work and reports -- appear to account for only a minor fraction of variance in the performance measure. However, we would do well to remember the following:

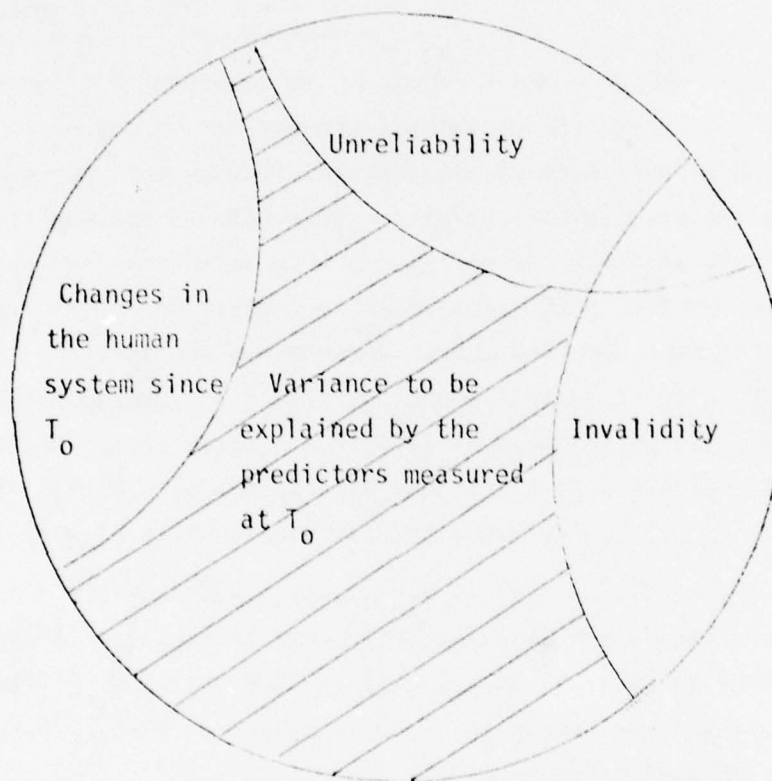
- (1) Part of the operational performance measure is error, random or systematic, and couldn't or shouldn't be predicted. While we can't safely apply a correction formula to the obtained coefficients and then use them in prediction equations whose ultimate purpose is value attribution, we would do well to keep this shortcoming in mind. In principle, it reduces the variance which we should expect to predict.

- (2) Part of the "true" performance variance which exists at any given time represents carry-over effects from previous system states which may no longer exist but whose impact continues to be felt on outcomes. Although, in principle, these effects ought to have been taken into account when those earlier system states were studied, in point of fact we have not as yet studied them over extremely long -- or even moderately long -- time frames. Their impact is therefore unknown.

Yet, another factor affecting the relationship between the criterion (measured at time  $T_0+k$ ) and the predictors (measured at time  $T_0$ ) is concurrent relationship between criterion and predictors at time  $T_0+k$ . In other words, the level of performance today is a function of the state of the human system, both today and the way that it was in the recent past. Thus, any changes in the predictors since their measurement at  $T_0$  would influence performance today at  $T_0+k$ . A possible representation of these factors which affect criterion variability is given in Figure 5.

To summarize, our predictions may, in fact, be far more accurate than the obtained coefficients would suggest. For one thing, some portion of variance in the performance measures is unreliable, and, of the reliable variance, some portion is invalid -- that is, doesn't really reflect the performance in question. If we simply use squared (or multiplied) coefficients as indicative of variance, and hypothetical values of .80 as indicating reliability and validity in the criterion measures, we would have  $.80 \times .80 \times .80$ , or .51 as a possible "upper limit." In other words, we might in fact, be predicting all that there is to predict.

Figure 5



CRITERION VARIANCE

at some time  $T_0 + k$

### III. ISSUES OF DATA TRANSFORMATION AND THE TRANSDUCER FUNCTION

Other than in pure mathematics -- if there -- numbers in their own right have no meaning. This is particularly true when the numbers in question represent measures of human behavior or of system performance. For example, when a questionnaire is used to assess human behavior in an organizational setting, we begin with raw responses and work toward various aggregate or transformed measures. The raw responses of each member of a particular organizational work group may be converted to index scores by calculating a mean of component items. The mean then represents a central tendency of item responses for that particular individual in that index area. Taking a next step, we might represent the whole work group by calculating a mean of individual index scores for the persons making up the group. Now the score represents the central tendency of group members. In each of these instances, we have transformed the measures from simple collections of unrelated numbers to something with somewhat different meaning.

Interpreting these numbers may lead to additional steps, however. First, we may simply relate each group mean to the wording of the original scaled response alternatives. If we do, our expectation is that a mean score reflects the meaning implicit in the wording of the alternative(s) closest to it.

This also may be inadequate, however, and we may choose to convert each score to a z-score, which is stated in terms of the dispersion of the scores in the sample. Finally, we might decide to convert each score to percentile form, either on the basis of our expectation derived from its z-score, or on the basis of an actual "line-up-and-count" arraying of scores themselves. Again, in both of these instances we have restated the score in terms derived from an expectation of some sort. We have transformed or converted the score to a form in which it has currency for use by some portion of this system or related systems.



In systems theory terms, what this exemplifies is an example of part of the transducer function -- the conversion of information to a form in which it can be circulated, interpreted, understood, and used elsewhere. This conversion is accomplished by restating the numbers against some expectation base.

Standards are one example of a method of converting information to a form in which it can be circulated and used. By using performance standards, outcomes from various subunits within an organization can be compared, and their outcome information circulated across subunit boundaries in a meaningful way.

The process is relevant to the performance or criterion side of the relationships discussed and studied in this project. Total variable expense, for example, has -- here as elsewhere -- been stated in terms of "engineered standards." Stated initially in dollar form, expenses have been restated as a percentage of some base also calculated in dollars. These are typically historically based and reflect in part the capacity of whatever equipment may be used, but they reflect beyond this what has been experienced in the past for product mixes of particular kinds. An aggregation of the past thus becomes an expectation for similar situations or mixes in the future, and present experience is converted from raw "counting" form to a percentage of that expectation.

When, as in the cases represented in the reports of this project, performance is measured in terms of "engineered" historical standards, problems may be created in predicting future performance if the standards change between the time the equation is generated and the time future performance occurs. Such standards are commonly changed periodically to take account of technological changes, changes in work mix, and the like. For example, assume that future performance predictions in a garment plant are made on the basis of equations using performance measures computed in terms of present (past) standards. Such standards might assume five styles of four particular garments, each in a dozen colors. They would also be determined by crew size in relation to existing equipment and its capacity. Future value is, accordingly, determined in terms of a base using that performance capacity. However, suppose that the company decides to produce, for a mass market, only one style of one garment in six colors, and that it brings in faster sewing machines and

cuts crew size. Costs for a given volume of productive output are now presumably lower, and anticipated cost performances from improvement in the human organization must be calculated in terms of a "tighter" base.

In any ongoing current value system of human resources accounting, it would, for this reason among others, be wise to check continually the accuracy of prediction equations for revised-standard situations, and to update and change them accordingly.

The transportability of such information across the organization's boundary is less easy, however, even when historical standards are employed. The reason, of course, is that the means or methods used in determining standards may vary widely from organization to organization and from one time to another. This was one persuasive reason for the "dollar criterion" given by Brogden & Taylor (1950), and it is an equally persuasive reason for current value human resources accounting. In its normal or usual form, current value HRA not only anticipates future value, it also converts those changes into a metric with currency in a present time frame across organizational boundaries--a dollar metric.

In this sense, current value human resources accounting is an organizational example of an output transducer. As such, its role is clear: the conversion of performance information into a form which can be circulated and understood by important role occupants in other, sometimes superordinate, entities.

Here also the conversion operation is an example of the information transformation part of the transducer function. The value attribution process in current value HRA carries this a step further, by the three-step sequence of (a) converting the added value back to dollar form, (b) discounting it to reflect opportunity costs, and then (c) capitalizing it in order to cost it into an investment metric. Just as there are examples in planned organizational change of input and throughput transducers, so these processes of value attribution represent instances of the functioning of an output transducer, a sub-system rather ignored in most formal theorizing.

Let's consider this two-step transduction function in roughly that sequence, starting with the calculation and recalculation of "standards." In constructing a current value HRA system, we begin by calculating predictive equations, using criterion values derived from ratios of actual dollars expended to a then-current standard of expected dollars. We converted to anticipated gains and losses by removing the denominator -- the base or standard. However, if standards are changed between the time that the equation was generated and the time for which prediction was made, there are problems. The values to be realized from gains and losses in that future period (now presumably arrived at) are different from those that would have occurred had old procedures, old standards, and old values remained in effect. Stated in transducer terms, the values have been converted to a form that is either no longer capable of being circulated, or is, more likely, misleading.

Turning to the second of the issues, we may perhaps add usefulness of the current value procedure by understanding the transducer function as it applies to outcome measures and extrapolating this meaning to a Navy setting. In the case of the Navy, the relevance of a dollar metric to all aspects of its performance is not immediately obvious. Stated in question form, in the absence of dollar convertibility -- which may well occur for some Navy outcomes -- are there analogs to discounting and capitalization? What sort of transducer function would be maximally useful for readiness, for example?

Thinking about this issue draws us rather naturally to searching for some sort of analog in the area of ultimate system criteria. For industrial enterprises, ultimate outcomes are placed on a hypothetical scale that runs from enduring profitability on the one end to bankruptcy on the other. Although the manner of measuring them may not be immediately apparent, the military analogs of these two states are not hard to find -- they are victory and defeat, respectively. Just as the attaining of a simple profit at one point in time does not guarantee enduring profitability, so one victory does not guarantee victory forever. Bankruptcy can be rather final, however, as can defeat. In each instance, the ultimate consequence cannot be assessed in advance. Stated otherwise, no equations conclusively predicting system demise are available or even subsequently useful, and none for ultimate success can ever be met.



Instead, what one does is to assess and evaluate events or occurrences of some penultimate kind that are presumed to be instrumentally related to ultimate ones. In industrial settings we predict total variable expense or absenteeism because it is presumed to relate to profitability of the firm. Similarly, in military settings we might predict readiness, or reenlistment rate, or discipline because a ready, experienced, disciplined force is presumed to be likely to win in a military conflict.

Extracting the obvious meaning from this, as we turn to the possibility of a current value human resources accounting system for the Navy, we need remind ourselves that the procedure, not necessarily the dollar metric, is the critical issue. In industry, current value HRA calculates in dollar terms because dollars are the metric used by profit-making enterprises and those policy or decision-makers who direct or influence them. Even here, other metrics might be possible, however. Indeed, developments at a societal level suggest that the years ahead may well see the development of "quality of life" or "social responsibility" or "environmental" metrics.

Whatever the metric(s), the purposes remain the same: to convert organizationally added value into metrics which have currency among members of the Navy's management subsystem and among those external entities and agencies whose decisions are critical to the Navy (e.g., Congress). One of these metrics may be, in fact, the dollar, where costs and appropriated resources are the issue of concern. Certainly some aspects of Navy performance are dollar-convertible. For example, the costs of attrition or of low retention rate in critical ratings are in part expressible in dollar terms. However, the ultimate criterion of Navy unit performance is not simply the hanging on to as much manpower as possible, at the lowest possible cost, but the defense of the nation, and the non-economic aspects of this criterion are not obviously dollar-convertible. The cost of losing a war is only in small part economic, for example. Its social and political consequences might well be disastrous, in ways not calculable in dollars.



Perhaps the closest approximation to this ultimate non-economic interior is readiness, defined as an ability to cope with any military contingency that might arise. As we have noted in earlier reports, work by Dunnette, et al., may be viewed as identifying readiness as one of three critical criterion domains (Dunnette, et al., 1973). It may well be therefore, that current value human resources accounting in Navy settings must in part be cast in terms of something like "readiness units" that are the analogs of dollars in industrial (and some, or a portion of military) organizations.

If such a metric existed, its units would represent increments and decrements in preparedness, and the function of a current value--or future performance trend indicator--system would be to anticipate changes in that readiness state that are attributable to improvement or deterioration in the human organization. Because it is a problem in anticipation, the analogs of capitalizing and discounting in commercial settings must be at least conceptualized, if not developed. Regardless of the metric, the purpose remains (a) to predict changes in outcomes, (b) to convert those changes into values on the metric appropriate to relevant decision processes, and (c) to adjust the resulting figures for the impact of time, however that occurs.

Let us examine each of these in turn, beginning with discounting. In commercial organizations, one discounts to take account of opportunity costs -- that is, the value foregone by virtue of using assets for the investment being discounted. Similarly, one capitalizes to address the question of what kind of investment would normally be required to yield a return of the kind predicted or experienced. As stated, these are not thought of in symmetrical terms -- that is, one experiences opportunity costs, but never opportunity gains. An investment required to reap a given gain is similarly always positive, never negative. Furthermore, the operationalization of these asymmetrical processes is made relatively easy by the fact that recognized standards exist -- the current interest rate, and the current rate of return by industry.

The whole notion of discounting is customarily stated in positive terms, that is, in terms of desirable outcomes which must be awaited. and of alternative good things which must be foregone during the interim. The central concepts are that (a) the real increment is worth only the excess of its long-range positiveness over that of the most desirable interim alternatives, and (b) both outcome, alternatives, and original investments are stated in terms of the same metric. Among the perspectives not ordinarily taken by the notion of discounting are (a) "negative discounting," that is, the added interim value of postponing a negative consequence into the future, and (b) any situations in which either alternative outcomes or original investments are not stated in terms of the same metric as the discounted consequence.

Still, one may raise the more general question that discounting suggests: does delay add to or detract from the value of a future consequence? Is some value foregone because of its futurity? In the industrial case of dollar returns and only a dollar metric, the answer seems fairly clear: delay does detract from the value of an anticipated return, because of the alternative returns that one might have gotten in the meantime. In the case of the Navy, the answer is not so clear. Perhaps an ability to realize a substantial increment in readiness ten years hence adds to, rather than subtracts from, its present value -- it may well make unnecessary a number of interim "patchings," discourage a potential aggressor who fears future retribution, etc. Or, alternatively, it may well follow an analog of discounting directly -- by making an enemy willing to take greater risks in the meantime, in the face of long-terms disadvantage.

For Navy organizations, there may be no obvious analogs of only positive returns and recognized rates. The processes may, indeed, be symmetric, and recognized standards may be hard to find. Consider first the issue of symmetric discounting. As an analog to its classical form, in a Navy setting one could imagine investing resources (not necessarily economic) in an upgrading of the human organization that is expected to pay off in readiness terms in three to five years. Doing so diverts those same resources from alternative uses that might generate immediate readiness. If immediate increments in readiness have positive value, then the investment must be discounted conventionally by some means.

however, the difference is that, unlike dollars, additional units of readiness may not always be positive in value. For example, immediate increments in readiness might cause a potential adversary to launch an attack in which one's own focus are disadvantaged, whereas future increments from a human organization investment might pay off handsomely at a critical time. In such a situation, one ought not discount (i.e., reduce) the value of future performance, but rather augment it.

Although less clear, a similar set of considerations might be applicable to capitalization. When one capitalizes a return, one addresses the question of how much by way of resources (a positive thing, measured in terms of the same metric as the outcome) one would have to invest (give up, put to work now) to realize that level of return (outcome). It is stated in this asymmetric fashion because, in commercial organizations, it never occurs otherwise.

But in military settings, it may well occur otherwise. One may not have to forego readiness now to realize a return later. Perhaps both may grow, with the answer to the classical question--how much must I put up (spend)?--being "Nothing at all," or "We'll pay you to do it!" In slightly different form, perhaps a present problem (cost) can be avoided or solved by that same investment that generates a future readiness return. For example, perhaps by upgrading the human resource processes of Navy units one can (a) immediately trim attrition, enhance retention, and reduce disciplinary infraction, while (b) creating a set of conditions that will pay off in increased future readiness.

The absence of an immediately recognizable analog of the going interest rate and of the average rate of return for each industry is rather troublesome. Their existence and acceptance in the commercial sector prevents much (but not all) squabbling. Still, opinion is never unanimous in their application there. For example, the going rate is one thing, but the deviation from that that you would likely experience in your situation may be quite another. The average rate of return is just that--average. What you, in your situation, have a right to expect may be low or high in the distribution for the industry. Whatever the opinion, the answers derive from the same processes that an answer for the Navy situation would, and must, come from: past experience, extracted, derived, and analyzed.



Again, the more general question is instructive: how much would one have to risk (e.g., in readiness terms to attain this level of increment in future readiness? For example, it might happen that there are a series of actions which, if taken, have a high likelihood of adding significantly to future readiness but which carry (a) some risk of failure, and (b) some possibility that we might lose readiness altogether. (Other examples might cross criterion lines in ways not occurring in the dollar-based industrial sector, as, for example, improvements in future retention rates which cost severely in immediate readiness, or improvements in future readiness which drive out all experienced personnel and generate discipline problems bordering on insurrection.)

For both of these output transducer operations -- discounting and capitalization -- military analogs seem highly likely. The difference is that, unlike the comparatively simple operations which have been well worked through by the financial community using a dollar metric, the ties between present and future, investment and return, opportunities and their cost, have not yet been worked through in quite these terms for military organizations. Yet, certainly some ties must be held to exist between military logistics, strategy, tactics, and policy, and those expert in these related fields might well provide the needed guidelines.

In any event, it seems sufficient to say that limitations upon costing future changes into a proper present framework need not prevent our taking the more basic steps of present value HRA for the Navy -- estimating future performance returns from present organizational changes in functioning and management.

The thrust of these issues, therefore, is that the application of current value technology to Navy organizations in non-dollar-convertible sectors must involve an answer to the questions just explored about a readiness metric. The task, while large, is certainly not an impossible one. Furthermore, it may pay dividends outside the area of predicting and interpreting future performance. It may well permit an analysis of policy implications of different readiness states that is not presently possible.



#### IV. EFFECTS AMONG PREDICTORS

A significant concept underlying the *Future Performance Trend Indicators* methodology is the accuracy of prediction. While the strength of the relationship between the predictors and the criterion is one aspect to measure that capability, there are several other related issues which impact the accuracy of prediction.

##### Consistency across Units

As stated in earlier reports (Davenport, et al., 1977) the nature of the relationship between the human system and performance may differ across organizations. This difference may be due to a variety of factors, two of which may be: (1) the quality of the human system, and (2) the type of work performed. The presently available data set on which this research has been based neither suggests nor denies these possibilities. Rather, they are questions being raised in the critical investigation of FPTI methodology.

The first possibility indicates that the criterion-predictor relationship would be different for work groups with high quality human interaction (high S00 scores) than for those with low quality (low S00 scores). In order to test this possibility, one would need a fairly large data set containing work groups with low and high S00 scores, and from the same type of work setting. If, in fact, this conjecture should be confirmed, the implications would be more significant at the inter-organizational level than intra-organization. This results from greater homogeneity of S00 scores within a single organization than across organizations. One inter-organizational implication is that one ought not transport a prediction equation from one organization to another without first checking on the comparability of the S00 scores. Another is that one would not want to group varied (by S00 levels) organizations into one super-organization on which to do analyses. The intra-organizational implication is that the accuracy of prediction will be a function of the homogeneity of the work group S00 scores.

The second issue identified above is the possibility that the criterion-predictor relationship would be different for work groups with significantly different organizational tasks (e.g., manufacturing & accounting). In order to ascertain the accuracy of this proposition, the data set would need to contain a large number of work groups with comparable S00 scores, but with diverse work tasks. The implications of this possibility for the FPTI methodology are many. In most medium to large organizations, while there may be one or two major functional areas with sufficient numbers of work groups to reliably estimate the criterion-predictor relationships, in many of the other task areas there are inadequate numbers. Thus, the single organization would either need to use a somewhat inappropriate predication equation for these other task areas, not predicted for them, or use a prediction equation developed across several organizations for a specific task area (e.g., accounting).

One possible difficulty which may arise and lead to erroneous support for the above proposition is the definition of performance. Specifically, if the performance measure is not consistently defined across different task areas, then differences in criterion-predictor relationships across task areas may result from differences in measuring performance rather than any real difference in relationships due to task areas.

#### Consistency Across Time

Regardless of how the prediction equations are developed, consistency of the criterion-predictor relationships over time are a concern. That is, if the relationship changes, even slightly, from the time period from which it was developed to the time period to which it is to be applied, the accuracy of prediction will go down.

One technique for developing the prediction equation:

$$(1) \quad \Delta \hat{Y} = B \Delta X$$

would be to have full, two year data on both performance (Y) and S00 (X). Then, by forming  $\Delta X$  and  $\Delta Y$  values, estimate B. Even so, to evaluate the consistency of this relationship, one would need comparable data over several years, and preferably for several organizations.

In the present study, full, two year data was not available. Thus, the above procedure was not feasible in deriving equation (1). The alternative was to derive (2)  $\hat{Y}_1 = B_1 X_1$  and then assume that  $B_1 = B_2$ , yielding (3)  $\hat{Y}_2 = B_1 X_2$ . By simple arithmetic, it follows that:

$$(4) \quad \Delta \hat{Y} = \hat{Y}_2 - \hat{Y}_1 = B_1 \Delta X.$$

In this situation, the requirement of consistency of the relationship across time is even more evident.

Lapointe, et al. (1978), looked at the assumption of  $B_1 = B_2$  with the very minimal data available within this study. They found no substantial evidence to support or invalidate this assumption. (See also the later remarks in this section regarding multicollinearity.) The implication of inconsistency across time, if it is established, is that organization's will be forced to use less than optimal prediction-equations, resulting in loss of accuracy in prediction.

### Multicollinearity

The existence of multicollinearity implies that one or more of the predictor variables is a linear function of other predictor variables. Past analyses of the 13 predictor variables (500 indexes) used in the present study have shown that the correlations between the predictor variables range from .5 to .7 (Franklin, 1973). Thus, none of the predictors are really linear functions of any other single predictor. However, they clearly are interdependent.

Interdependence among the predictor variables has the effect of increasing the variability of the estimates of the true regression weights (the standard errors of  $(b_1, b_2, \dots, b_{13})$ ). That is, any estimate  $b_i$  of the true value  $B_i$  is going to be less reliable as the degree of interdependence increases. The implications of this lack of precision are not more variable estimates of the criterion, but rather, less likelihood that there will be agreement between one prediction equation and another, both computed from comparable samples from the same population. Any one prediction equation generated from a multicollinear data set may give fairly accurate predictions. However, confidence in the equation's ability to do this will be relatively low.

The lack of reliability in the estimates of the beta-weights (regression coefficients) resulting from high levels of multicollinearity makes it virtually impossible to accurately test consistency of the criteria-predictor relationship over time. That is, if  $B_i$ ,  $i=1,2$  represent two different sets of regression coefficients for two different time periods, as identified above, the equality  $B_1=B_2$  is a concern. Any attempt to test this null hypothesis with highly multicollinear data almost guarantees rejection, regardless of its validity.

A fuller discussion of multicollinearity is given in Appendix A, as well as further analysis with respect to the present data set. The conclusions are that, while there appears to be a fairly high level of multicollinearity, the effects are not as theory would prescribe. Clearly, a more thorough investigation of multicollinearity, theoretical and empirical, is indicated and its impact on predicting performance.

#### Linearity of the Criterion-Predictor Relationship

A final issue which may affect the accuracy of the prediction is the accuracy of the model. While the assumption of linearity implicit in

$$\hat{Y}=BX$$

has been empirically examined for the two criterion (TVE & ABS) used in this illustrative study (see Davenport, et al., 1977), other choices for the criterion would necessitate re-examination of this assumption.

In the multivariate setting, the ability to examine the degree of fit of a model to a data set is not very high. This generally involves plotting residuals against various other variables, and visually interpreting these graphs. A second aspect is the possible extension of the model beyond the limits for which it has been developed. For example, a particular model may fit the data fairly well within a particular range of predictor scores which are present in the developmental sample, but not at all well when extended to the new predictor values. These latter values may result from significant interventions to improve the quality of the human system.



### Number and Nature of Predictor Variables

One concern which affects several different aspects of the FPTI methodology is the number of predictor variables involved. In the present situation, 13 S00 indexes have been used. In further investigation and application of FPTI, two natural questions arise: (1) Are there other aspects of the human system which ought to be measured and included in the prediction phase?, and (2) Is there any way to reduce the number of predictor variables?

The two, if both answered in the affirmative, appear to be in competition with each other. It may be however, that a good solution to the latter would negate, and possibly even be enhanced by any increases resulting from the former.

The present version of the S00 has 16 major indexes. Three of these were not used in the present work, mostly because of lack of information (resulting from modification of earlier forms of the S00) from some sites. However, as continual research evolves, it may well demonstrate that presently unrepresented aspects (by the 16 S00 major indexes) of the human system relate strongly to organizational effectiveness. Possibilities may include inter-unit coordination, job complexity/freedom, career paths and accessibility, bureaucracy, and organizational-individual goal integration. Clearly, there are several possibilities, and some other criteria rather than simple availability will need to be established for the addition of variables into the FPTI process.

The above discussion is somewhat reminiscent of the concerns introduced by Davenport et al., (1977) regarding modifier variables. The purpose of human resource accounting must be kept in mind: the monitoring of the state of the human system, so that its impact on performance can be known. Thus, one criteria for inclusion of variables ought to be that the variable is a measure of some aspect of the quality of the human system. Variables that relate to structural or technical aspects of the organization ought

not to be measured for this purpose. The inclusion of modifiers which increase the accuracy of prediction is acceptable as long as any predicted change is not due to changes in the modifier, but to real change in the quality of the human system.

In an effort to decrease the number of predictors, Lapointe et al. (1978), investigated the exclusion of some of the 13 S00 predictor variables used in this study. The results indicated no single variable ought to be excluded over time. A slight modification of this approach may be of interest, however. In particular, are there subsets of the predictors which could be used in different time periods?

In further research, it may be possible to demonstrate the existence of theoretically consistent subsets of S00 indexes which have maximum effect on productivity in, say, the three time frames, 0-3 months, 4-8 months, and 9-18 months. If in fact, this is true, and the subsets run, say, to 7 or 8 variables, the resulting reduction in the number of predictors would be extremely helpful.

While the description of such a possibility appears fairly straightforward the actual determination of these subsets of predictor variables would be quite complex. In addition to the definition of appropriate time frames, the less evident issues, e.g., "What to do at the boundaries?" and "Are the subsets criterion dependent?", would also need to be addressed. Regardless, the concept is theoretically consistent and desirable in application, and ought to be investigated.

## V. PROBLEMS OF STRUCTURE AND SUBSETTING

The observation has been made that, in organizational life, structure is nothing other than "frozen process." Nevertheless, persisting patterns do come to form enduring realities, and both the level of that reality which we choose to deal in and events that bring noticeable changes in it present problems which can affect prediction and therefore utilization.

### Problems of Subsetting

Once we subset an array of persons to correspond to organizational structure and its concomitant events, we may find that we have done some rather peculiar things to the pattern of relationships of one measure to another. One such effect is what is known as the "ecological fallacy," which in this instance simply means that events at one level may move in an opposite direction to those at another.

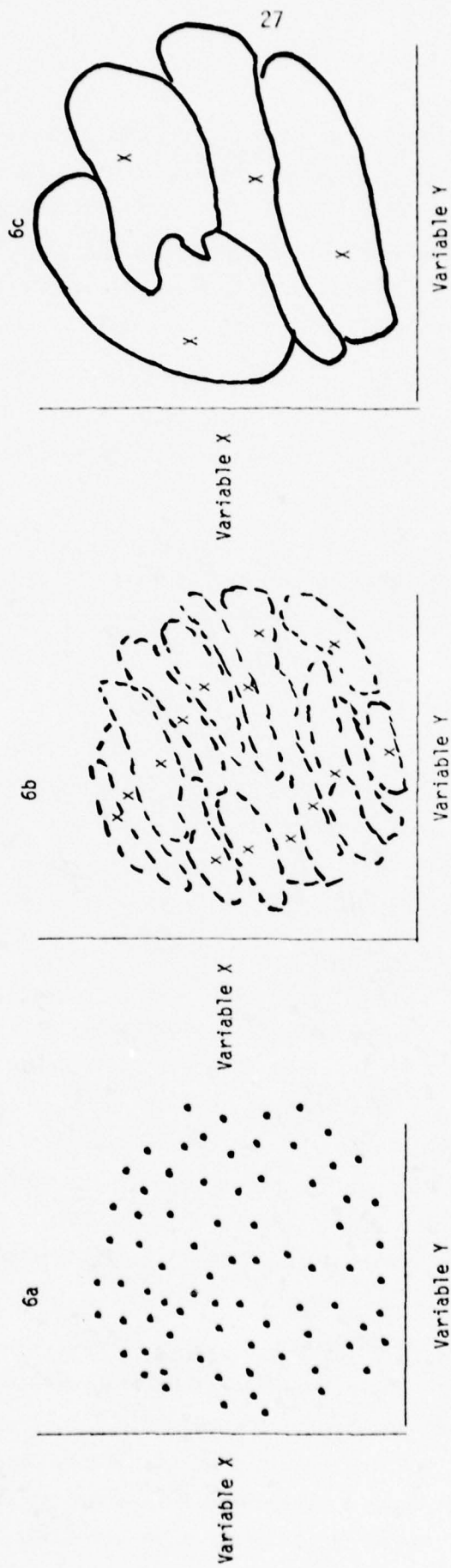
This is illustrated in Figure 6a, where a pattern of dots is used to depict a bivariate relationship at the individual respondent level. As is obvious, the pattern is for all intents and purposes spherical, and the resulting coefficient would suggest that no relationship exists between these two variables at the individual level.

However, these persons belong to work groups indicated in Figure 6b by dividing the total distribution into subsets. Each group is depicted by its boundary, while its mean is indicated by an x, and the pattern of these means would suggest that a negative relationship exists between these two variables at the group level.

The illustration carries the process one step further. Suppose that these groups belong to four organizations, indicated by Figure 6c boundaries. Organizational means are indicated by X's, and the pattern of them would suggest a low, but positive, relationship.

Although this situation may seem at first to be a bit far-fetched, there is more than a small likelihood that it occurs in real-world situations. Indeed, some suggestion has been made that it appeared in a multi-level analysis conducted by one of the present authors in an earlier study of the relationship of interpersonal support to reenlistment intention. (Bowers, 1973)

Figure 6



x = work group mean on Variable X

X = Organizational mean



Let us further illustrate the process in terms of a question much discussed in recent years: do more participative management practices result in a stronger reenlistment intention? Using the data displayed in Figure 6 as if they were real, the answer at the individual level would be that these practices make no difference in reenlistment intention -- that there is no relationship of one to the other.

However, another investigation might conceivably take these same data and correlate the two variables at the work group level. If so, the conclusion would be that participative practices result in a lower intention to reenlist.

Yet another investigator might decide that only whole organizational units -- e.g., ships -- are sensible units of analysis and therefore correlate organizational means for these variables. In this case, his conclusion would be that participative practices result in higher intentions to reenlist.

Although termed the "ecological fallacy," the situation may represent nothing fallacious at all. Each effect may be very real and very true. Effects not present for individuals simply may very well be present for meaningful groups of those individuals. Groups, in their turn, may be clustered in a way that produces contrary aggregate effects.

A major utilization problem for any system of future performance trend indicators may lie in the possibility that these effects can occur. Human resource-oriented practices may be seen as having quite different effects at each of these levels. At the level of the single individual, there may be little or no relationship between the strength of these practices and the attitudes of Navy personnel. At the work group level, however, the relationship may be strong, positive, and quite evident. Nevertheless, the evidence may well be rejected at whole command levels where it runs counter to negative relationships experienced by commanding officers at that level.

A crucial requirement, therefore, is that we determine as accurately as possible which effects are causal in nature and represent potential action variables -- "handles" on the observed problem -- and which are the result of coincident subsetting. (For example, it may happen for some very good reasons that work groups whose managements are less human resource oriented are clustered into organizations whose situation leads to high

reenlistment rates. However, if one were to shift all of their groups toward a more human resource oriented set of practices, the shape of the distribution of organizations might be fundamentally changed in a constructive direction.)

Yet another subsetting problem may occur when units' performance is calibrated in terms of historical standards. For example, in one of the organizations included in the present study (and a reason for removing its data for some periods), it was noticed that the correlations of supervisory leadership and other measures with total variable expense dramatically and suddenly changed direction in certain months of the year. A bit of digging produced an explanation that was simple, yet perplexing. Over the years, some units had been well managed and were highly efficient. Their historical standards were therefore tight or stringent, and both their human resource practices and their performance were perennially good.

By way of contrast, other units had been badly managed, their performance as a consequence was relatively poor, and their historical standards were "loose." Because it operated in a high technology area and had a need for skilled personnel, the company had a "no layoff" policy. At certain times of the year, therefore, when business predictably dropped off, the overmanned, "loose" units had far more surplus bodies to dispose of than did the better managed units. Accordingly, large numbers of persons were temporarily shifted from the ineffective units to the effective ones. Their time was now charged against the budgets of the effective units and removed from the budgets of their ineffective parent units. Accordingly, the performance of the "good" units became suddenly poor, while that of the ineffective units seemingly improved. Furthermore, each was roughly proportional to their historical goodness of poorness, and the correlation coefficient accordingly changed sign but maintained a great deal of its strength.

As in the case of the "ecological fallacy," this form of subsetting problem could easily be misleading and result in non-utilization of any system of future performance trend indicators. Where anomalies of this sort occur, it is accordingly important to determine the reasons. As an added check on the possibility that certain subsets have relationships to criteria that differ from one another, one might break an entire data set into major

functional or other subsets and separately correlate measures. A more complex and tedious procedure would be to break an entire data set into subsets that do correlate differentially, and then determine whether the subsets so generated make any organizational sense.

#### Structure-Related Consideration

Any real-world application of the current value method of human resources accounting employed in this present study would avoid the major problems of selecting a subset of work groups for value attribution purposes. Because all groups would be included and the necessary data built in as available from the start, little purposeful selection would be required.

Still, there would be some persisting aspects of the problem, attributable to (a) growth or structural change in the system, and (b) the nature of existing management information systems. The problem is perhaps clearest in the case of structural changes which result in the disappearance of some units, the creation of others, and the serious modification of still others. For example, a situation could easily occur in which a unit, present at Time 1 and instrumental to the generating of the equations, totally disappeared before Time 2. In such an instance, it would be possible to simply go ahead and predict performance from Time 1 scores for such a unit, but distortion might thereby be introduced.

Still other changes result in the disappearance of units, but the persistence of their functions and former members. In such situations, one might use the unit's Time 1 scores and the old standards and make a prediction as if it still existed. The prediction would be added to the aggregation and presumably in some way reflect the persistence of its personnel and mission. However, a more consistent method would be to compute new standards for the performance of the revised structure and then predict for the units of this new structure.

Similarly, where a new group is created by Time 2 which has no Time 1 counterpart, we might simply assign a Time 1 score corresponding to the class mean at Time 1 for all other scores with that same Time 2 value. Where large-scale structural change has occurred, however, distortion would occur from the fact that stable units will very likely be atypical.



Finally, where reorganization results directly in changes in standards, one must adjust prior value increments accordingly. For example, a maintenance unit might be broken up and its personnel reassigned to operating units. In such an instance, some of its predicted future performance will now affect changes already predicted and valued for the units to which its personnel have gone. Those earlier predictions must accordingly be corrected.

A somewhat different set of problems occur for units -- primarily staff and upper level management -- for which typical information systems may maintain no record of performance. In principle, personnel criteria such as absenteeism are extendible to all units, line or staff, management or non-management. In practice, these may not exist, however, for reasons having to do with non-union, exempt status, with record-keeping systems that are more permissive at these levels, and the like. Similarly, while the productive output of staff and upper management groups is in principle measurable, in practice it is not measured. Instead, measures of formal output are obtained only for bottom-level line units. It is applied to others only by generalization within. For example, the productive output of a general foreman's group of foremen might be set as equal to the average output of the groups in their departmental domain.

One cannot safely extrapolate outside of units, however -- to staff units from a parallel operational unit, for example. However, if one were to simultaneously predict for the total organization (not as a sum of work units) and for those operational units for which performance measures are available, the predicted change attributed to the non-measured units could be estimated by the difference between the two. This may be illustrated by:

$\hat{Y}_{TO}$  = predicted change for total organization (where the total organization is the unit of analysis),

$\hat{Y}_{OU} = \sum \hat{Y}$  = sum of predicted changes from operational units

$\hat{Y}_S$  = predicted change for non-measured units,

then  $\hat{Y}_S = \hat{Y}_{TO} - \hat{Y}_{OU}$ .

The other alternative, of course, would be to define and monitor appropriate performance measures for such units.



### Unit of Analysis

Conceptually, Human Resource Accounting techniques could be developed using any of the following as the unit of analysis: individual, work group, cost center, department, division, or organization. By unit of analysis, we mean the unit or level at which both performance and the quality of the human system is assessed. It is the purpose of this section to explore issues, both theoretical and statistical, which relate to the unit selection, as well as discuss the ramifications of the procedures used in the development of the FPTI methodology as presented in this series of reports.

There would appear to be three major components which optimally are integrated when selecting the unit of analysis for a HRA system. The first is the theory of organizational functioning which is necessarily conceptually sound, and, more importantly, appropriate to the organization at hand. One such theory is that of Rensis Likert (1967) which involves overlapping (vertically) work groups, each supervisor being part of two work groups: the one which is to be supervised, and the one which is composed of all those reporting to his/her supervisor. This conceptualization of organizations has been vigorously examined and been shown to be appropriate for a wide variety of organizations.

It is possible, however, that a class of organizational structures, or particular organizations will not fit the above model. One such class may be the matrix structures, where Likert's overlapping structure is insufficient. The authors are aware, also, of a particular municipal transit organization where, at best, 90% of the entire labor force have no supervisor, as such, and no substructure among themselves.

In the latter two cases, it would be important to develop a model of organizational functioning which is internally valid. As has been noted by Pecorella & Bowers (1976), one major criteria for developing FPTI is the ability to measure relevant aspects of the human system. The selection of these dimensions is clearly related to the appropriate model of organizational functioning.

This leads to the second of the three major components: the instrument used to measure the human system. The instrument must be consistent with the theoretical model discussed above. A specific facet of this consistency is the unit of analysis. For example, if the theory presumes the individual employee is the basic unit, then it is necessary that the instrument measure aspects of organizational functioning at the individual level. One subtlety in selecting 'off-the-self' surveys is ensuring the fit of the theory base of the instrument and the appropriate organizational theory. In surveys developed for a particular use or setting, it is both difficult to have them theory based as well as internally consistent.

The third aspect which needs to be integrated with the first two is the performance measures. While often times present performance measures represent several layers of aggregation, it would be possible to measure them at the lowest level - i.e., the individual. One such example would be the penultimate measure of absenteeism. However, in other settings, it may be difficult to actually assign a present performance measure to each individual. Two alternatives exist in such circumstances: impute aggregated values to the desired unit (e.g., individual), or devise new performance measures which can be enumerated at the desired level. As discussed later in this section, frequently the former leads to erroneous statistical conclusions.

The level at which performance is measured does not have to be at the same level (unit of analysis) as the theory of organizational

functioning and human system measurement. Although, as discussed below, the continuity across all three is the most desirable state. Aggregation or imputation can cause errors in interpretation and precision.

### Ecological Fallacy

The principal concern with imputation or aggregation is the statistical phenomena known as 'ecological fallacy' (Langbein and Lichtman, 1978). This most frequently occurs when calculations based on data collected by groups is interpreted as applying to the individual components of those groups. For example, collecting individual performance and satisfaction measures from the members of fifty work groups, and correlating them, will most likely lead to somewhat different values than collecting the average performance (or the work group's performance) and the average satisfaction for each of the fifty groups and correlating them.

The existence of this phenomena is the principal reason to avoid aggregation and/or imputation. However, it should be noted, the danger comes in applying the results to subunits of aggregate groups, and no errors result if the interpretation is at the level which the data is collected.

### The Present Study

As discussed by Pecorella & Bowers (1976), the data set on which the present series is based includes performance measures by cost center. The Survey of Organizations, used to measure the human system, collects data by work group. Because of the sample size necessary to do the multiple regressions involved, the cost center scores were imputed to the work group rather than aggregating the work group scores to the cost center. (In this setting, a cost center is a budgetary unit, with known predicted costs and performance.) The purpose of this section is to discuss the implications of imputation from cost center to work group. These remarks are made in addition to, not instead of, the comments above regarding the ecological fallacy.

As mentioned above, in the present study, it was necessary to impute cost center performance values to work groups. In the development of the statistical relationship between the human system and performance, the effect of the imputation of cost center values to work groups is to decrease the variance between work groups. Thus, the accuracy of the resulting multiple regression coefficients are reduced, as is the accuracy of the computed prediction equations. Also implicit in this imputation is that the contribution to the cost center is uniform across work groups. As discussed below, this may well not be the case.

Once the prediction equations had been obtained, future work group values were predicted from the corresponding change in work group human system values. In order to do the value attribution phase, work group predicted performance values were aggregated back to the cost center. This was accomplished by taking the arithmetic average (mean) of the performance changes of the cost center's component work groups. Implicit in such a calculation is that the contribution of the component work groups is equal. This clearly may not be the case. Take, for example, the situation in which a cost center is made up of 9 non-supervisory work groups (say, three per shift) and one supervisory work group. Most organizational theorists would claim that the impact of the supervisory work group is significantly more important than that of any of the non-supervisory work groups. Thus a change in the supervisory work group ought to predict more than one-tenth of the total cost center change. Another example might be in a cost center comprised of three work groups with 10, 5, and 4 employees. It is likely that a change in the larger work group will have more impact on the cost center than comparable changes in either of the other two work groups. (The situation in this second example could be handled through the use of a weighted mean, if, in fact, the work groups are essentially not interdependent.)

Even if the number of cost centers available in the present data set had been sufficiently large to calculate reliable statistical relationships between performance measures and the S00, it may not have been wise to do so. If the cost center became the unit of analysis, then work group scores would be aggregated to the cost center. In many settings, such aggregation, usually done using



(weighted) means, makes sense theoretically. For example, an organization may have 40 district offices, composed of three to seven work groups. In this situation, computing a district office score as an average of the component work groups provides a measure of the district office's overall quality. The obvious interdependency of the work groups is the justification for the aggregation. However, in some cost centers, the component work groups may be effectively independent. Consider, for example, the single work groups that staff a particular machine across the three shifts. Other than coordination of maintenance, it is conceivable that these work groups have no interaction nor interdependency. The aggregation of work group attributes to the cost center may not measure cost center attributes which relate to performance. That is, attributes of work groups which relate to their performance may not be generalizable to aggregates of independent work groups.

Another problem with aggregating work group scores to cost centers is not knowing how each work group ought to contribute to that aggregation. If, in fact, the exact contribution of each work group to performance were known, then the aggregated SOO scores could be combined using the same relative weighting. However, such knowledge is rarely available.

A final consideration of the consequences of imputation in the present study involves the examining the accuracy of prediction. If, at the end of the time frame for which prediction was made, actual performance values were ascertained, and compared to the predicted values, interpretation of the comparisons is still difficult. If the scores compare favorably, fine. If, in fact, they do not, then two interpretations are possible. First, the ability to predict may be very low. Second, the process of aggregating predicted work group scores to the cost may be at fault, and the accuracy of prediction is irrelevant because of this.

In summary, it is important that the organizational theory, the actual organization, the human system measurement device, and performance data measurement be integrated. The optimal solution is that this be done at the same level using the same unit of analysis. For most organizations, this may well be the work group. It is important, for statistical reasons, to be careful in using grouped data to make inferences regarding the component units. Finally, in the present research, the limitations of the available data set reduced the accuracy of the product (but not the process).

## VI. CYCLICAL PATTERNS AND PERIODICITY

The FPTI methodology involves measurement, performance and the human (social) system. Whereas the existence of the relationship between the human system and performance is the crux of the entire methodology, each of the variable areas has aspects alone which merit attention, and may impact measurement procedures. It is the purpose of this section to review these aspects - for example, the life expectancy of changes in both performance and the human system - and their implication on measurement.

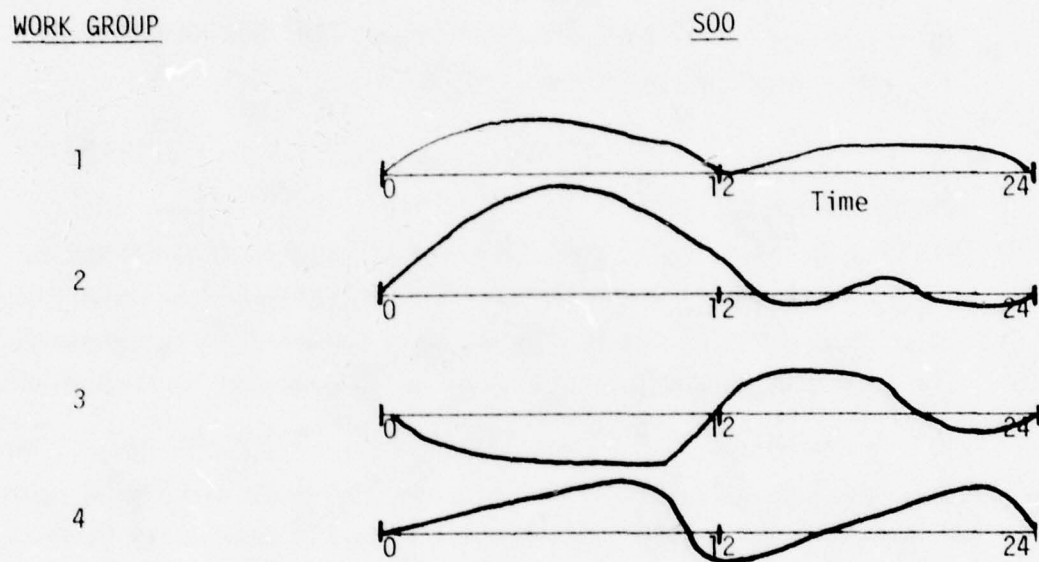
The Human System

The human system, measured by the Survey of Organizations, changes over time. However, little is known about the time framework in which those changes take place, or the expected duration of particular changes. However, both may affect FPTI.

As a first consideration, suppose a particular organization does on-going measurement of the human system at exactly 12 month intervals. If, in fact, most human system changes occur frequently, but short are ephemeral, it would be possible to get work groups whose S00 scores show no change (in  $n$  dimensional space) at the one year intervals, but, in fact, have significant variation within given years (See Figure 7).

In the above example, Work Group #1 would have no predicted change in performance due to no measured change in levels of the S00 (this being measured at 0, 12 and 24 months). Work Group #2 would have only a small increase in S00 for the first year, a small decrease for the second. For Work Group #3, an essentially negative change will not be offset by change late in the first year, so with the time lag, an estimated positive performance change will not appear. Just the opposite effect will hold true for Work Group #4 for the first year.

Figure 7  
POSSIBLE WORK GROUP CHANGES LEADING TO  
INAPPROPRIATE PREDICTION



What would be helpful to know, clearly, is the life expectancy of most human system changes. If the human system were monitored at time intervals less than this expected longevity, then the probability of inaccuracies similar to those indicated in Figure 1 would be minimal.

The above illustration is a simplification of actual human system changes. At any one point in time, there may be several, if not dozens, of different changes going on in a particular work group. These may stem from external sources - change of personnel, task assignments, organizational structure - or internal sources - increased skill, peer interactions, personal tragedies. Thus, regardless of the life expectancy of any one change, several are apt to be starting and ending in overlapping patterns. Thus, the summative pattern, if one exists, would be the principle concern of further investigation.

Implicit in the above discussion is the existence of cycles within the human system. This, in itself, is a question with different implications. One possibility is that there are no generalizable cycles, and the above concern about frequency of measurement is moot.

### Performance

In an earlier section, measurement of performance has been discussed in terms of reliability and validity. Here we wish to discuss both the span of predictability and the longevity of predicted performance changes.

One concern raised by the present research, but not answerable given the constraints of the available data set, is the limit of future predictability. That is, how far into the future can we prudently predict performance based on the quality of the human system today? Available evidence is suggestive of a span of predictability of at least two years, but it may even be longer. Organizational variables which may affect this include attrition, rotation policies, labor force growth, and demographic characteristics of the present labor force.



The other issue regarding performance is the life expectancy of the performance change. If, for example, a single unit improves in such a way that the resulting predicted performance change is valued at \$5,000, how long does this value remain assigned to the work group? The FPTI methodology would predict this change only for one year, whereas, with no other changes in the human system, the saving would go on indefinitely. In many circumstances, the increased performance would be incorporated into new standards, which also obscures the lasting value of the change.

#### Measurement

One question most organizations will have, if for no other reasons than logistics and cost, is 'how often do we need to measure the human (social) system?' Discussed above is the issue of frequency of measurement with respect to the pattern, if any, of human system changes. Other factors affecting the frequency of measurement also need to be weighted when making this decision.

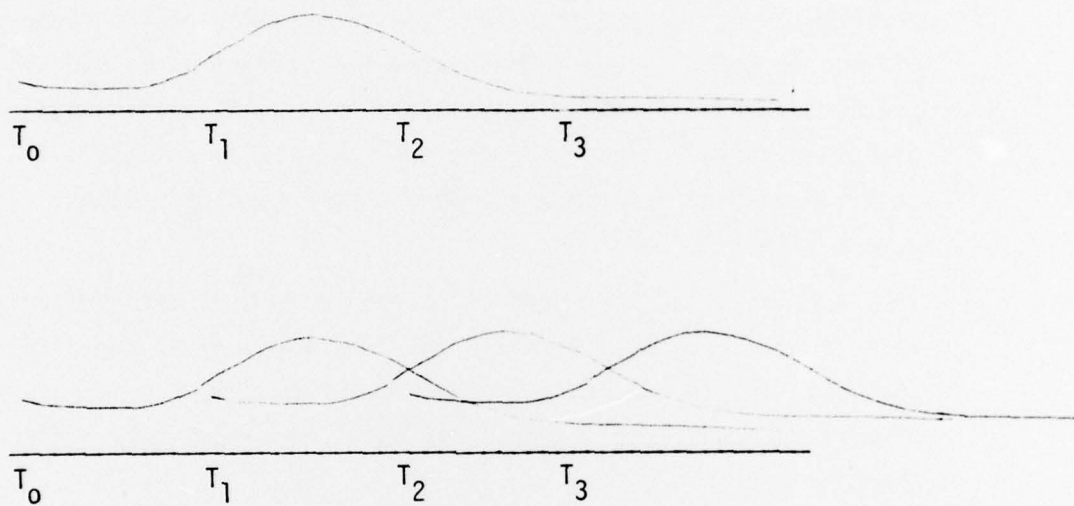
Clearly, measurement which is consistent with an organization's present accounting system would simplify integration of human resources accounting into the total accounting system. While conceptually it is possible to predict for different time frames than the periodicity of human system measurement, the complexity of statistical analyses and developmental data base required would make such a program very difficult to develop. The one exception to that is if the frequency of measurement is some even multiple of the prediction period. (For example, predict for one year, but measure every two years.)

Other aspects supporting, fiscal year (or multiples thereof) measurement are seasonal changes in work load and annual planned changes in performance standards, as well as its commonality.

Another problem develops, however, when one begins to predict for, say, the fourth year. The difficulty is pictorially demonstrated in Figure 8. If, in fact, it is now time  $T_3$  and prediction for the fourth year is to be made, which data ought to be used? Considered solutions would include a)  $T_3$  data only, b)  $T_2$  data only, or c) some combination of  $T_0$ ,  $T_1$ ,  $T_2$  and  $T_3$ . At time  $T_3$ , the performance of the organization is a combination of the concurrent effects as given by the human system measurement at  $T_3$  and all previous predictive effects (within the span of predictability discussed above). These effects are most likely not additive (not independent of each other) and thus demands additional investigation.

The answer to this prediction problem (which data to include) is presently unknown. Research into the adequacy of the different possibilities is needed, but it would appear that the inclusion of more than one year's data could assist in accurately predicting changes.

Figure 8  
LAG TIME OF FIRST CONDITIONS  
AND COMBINED EFFECTS YEARS LATER



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## APPENDIX A

### MULTICOLLINEARITY

Multicollinearity is defined as the existence of a linear relationship between one of the predictor variables and any subset of the remaining predictor variables. In the literature, however, it is often treated as a continuum, and reference is made to the degree of multicollinearity. Several authors (Rockwell, 1975 Farrar and Glauber, 1967, Haitovsky, 1969) have discussed multicollinearity and its effect on the accuracy of prediction. It is the purpose of this appendix to examine multicollinearity as it exists in the present data, its apparent effect on prediction, and implications for human resource accounting.

#### The Present Study

The existence of a high degree of multicollinearity is said to have the greatest effect on the reliability of the estimated beta-weights (regression coefficients). The reliability of these values is measured by the standard error (the standard deviation of the sampling distribution) of the beta estimates. This section presents both the measurement of multicollinearity and its effect on the standard errors.

In calculation of the beta weights, it is necessary to compute the determinant of  $\underline{X}' \underline{X}$ , where  $\underline{X}$  is the matrix of observed values. (If the values have been standardized, then  $\underline{X}' \underline{X}$  is the correlation matrix.) When one variable is a linear function of other predictors, the determinant of  $\underline{X}' \underline{X}$  is zero. One measure of multicollinearity, then, is the value of the determinant of the correlation matrix.

From the present data set, two waves of S00 data (the predictor variables) are available. The determinants of the correlation matrices for wave 1 and 2 data are both zero to more than 3 decimal places. This indicates a fairly high level of multicollinearity.

In order to examine the consequences of this interdependence among the predictors, the results of the cross-validation study completed earlier were examined (Pecorella and Bowers, 1976). At that time, the

the entire sample was randomly divided into equal subsets, and regression equations computed for each subsample. If, in fact, the estimates are unreliable, one would expect large standard errors. Table 1 presents the means and standard deviations of the standard error terms for both TVE and ABS equations (excluding the constant coefficient). As can be seen, the standard error terms are not large, nor variable, contrary to theoretical considerations. (The slight difference between TVE and ABS is partially due to different sample sizes.)

A second possibility is to match the estimated beta weights within each period across subsamples. The desirable goal is that the two values be very similar. The absolute difference between the two estimates were computed, and the results are given in Table 2. The magnitude of the differences is not really large, and thus somewhat contradictory to theoretical predictions.

The magnitude of the expected differences, while not large, is a function of the magnitude of the standard error. That is, it can be shown that the expected absolute difference is a linear function of the standard error. Thus, how large these absolute differences appear will be affected by the standard error values as given in Table 1. The final interpretation, then, rests on the interpretation of how large, and against what criterion, are the standard error terms.

### Discussion

The above results indicate a high degree of interdependence among the SOO indexes when used as multivariate predictors. However, the theoretically derived consequences seem not to appear. The implications of this paradox, as well as its very existence, are unclear. Clearly additional investigation, both theoretical and empirical, is indicated.

The entire field of social science is confronted with non-independent (non-orthogonal) predictors. Most suggested solutions to the problem have inherent shortcomings. (For an enlightening discussion of these, see Farrar and Glauber, 1967.) It would be of great interest and value if it could be demonstrated that the mathematically derived concept of independence does not have the consequences, at least in some settings, which are arrived at by the mathematical statisticians.

Table 1  
 MEANS, STANDARD DEVIATIONS OF  
 STANDARD ERRORS OF BETA WEIGHTS  
 FROM CROSS-VALIDATION REGRESSION EQUATIONS\*

Performance  
 Variable: TVE

PERIODS:	C		D		E	
RANDOM SAMPLE:	1	2	1	2	1	2
Mean	.21618	.22072	.20580	.21614	.21206	.22905
Standard Deviation	.02815	.02240	.02643	.02201	.02761	.02325

Performance  
 Variable: ABS

PERIODS:	A		B	
RANDOM SAMPLE:	1	2	1	2
Mean	.2872	.2850	.2497	.2442
Standard Deviation	.0460	.0282	.0344	.0261

\*Periods selected were those for which the split sample N's were greater than 150.



Table 2

MEANS, STANDARD DEVIATIONS  
OF ABSOLUTE DIFFERENCES BETWEEN  
BETA WEIGHTS

Performance  
Variable: TVE

PERIODS:	C	D	E
Mean	.2307	.2144	.2240
Standard Deviation	.2116	.1749	.1290

Performance  
Variable: ABS

PERIODS:	A	B
Mean	.2193	.1717
Standard Deviation	.1251	.1263

\*Periods selected were those for which the split sample N's were greater than 150.

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Bldg. 2, Washington Navy Yard  
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Office of Naval Research Code 450  
Arlington, VA 22217

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Trng/Res. Section  
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ONR Branch Office  
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ONR Branch Office  
1030 E. Green St.  
Pasadena, CA 91101

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Naval Aerospace Medical and  
Research Lab  
Box 29407  
New Orleans, LA 70189

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Chief of Naval Technical Training  
Naval Air Station Memphis (75)  
Millington, TN 38054

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Navy Personnel R&D Center  
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ONR Branch Office  
495 Summer St.  
Boston, MA 02210

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Principal Civilian Advisor for  
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Naval Training Command, Code 00A  
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